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LIFE CYCLE COST MANAGEMENT,
METHODOLOGY, AND CASE STUDIES

STUDY PROJECT REPORT
PMC 77-2

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: LIFE CYCLE COST MANAGEMENT, METHODOLOGY, AND CASE STUDIES

STUDY PROJECT GOALS:

To identify DOD directives that provide the guidance for life cycle cost management and to analyze O&S cost estimating methodology and life cycle cost analysis techniques. Lastly, to analyze representative case studies that are demonstrative of the techniques being used to manage life cycle costs.

STUDY REPORT ABSTRACT:

This study project examines the management policies that have initiated O&S cost control and the progress made on O&S costing methodology. Costing guidelines prepared by LMI are summarized to provide the reader with an overview of the guidelines content and a preview of CAIG O&S costing methodology guidelines. The RAND report on LCC analysis for aircraft turbine engines provides analysis methods that allows performance to be assessed with the present technology and determine cost and schedule risks. Further, commercial operational and maintenance practices are reviewed for military applicability.

Three case studies representative of LCC management techniques are discussed in detail showing the impact of logistics alternatives, reliability by design, and maintainability features that contribute towards reduced O&S costs and lower LCC. The cases were selected from a LCC Seminar held on 29 Sept. 1977. The Army's Black Hawk program, Navy's F-18 program, and the Air Force's ARC-164 program are the three case studies selected. Important lessons learned on all three of the case studies should serve as models for other programs to follow that are concerned with LCC procurement. The results of the case studies provide positive indications that LCC management does work and can provide affordable systems.

SUBJECT DESCRIPTORS: Design to Cost (10.02.07), Reliability-Availability-Maintainability (10.05.02), Integrated Logistics (10.05.04), Cost Estimating (10.06.01.01), Procurement Methods (10.07.03.01), Warranty Requirements (10.10.05).

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LIFE CYCLE COST MANAGEMENT, METHODOLOGY, AND CASE STUDIES

Individual Study Program

Study Project Report

Prepared as a Formal Report

Defense Systems Management College

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Class 77-2

by

Andrew H. Berard
Industry

October 1977

Study Project Advisor
CDR. Herbert P. Woods

EXECUTIVE SUMMARY

Operating and support costs of our defense systems have steadily increased during the last decade and, in many instances, are exceeding the cost of acquisition. To reverse this trend we must expand our management of acquisition costs to include the outyear costs and provide total life cycle cost management.

This study report concentrates on the advances made in O&S costing methodology and life cycle cost analysis research and analyzes how life cycle cost management is being accomplished on three of our current defense programs. This report should also be useful to those interested in some of the successful techniques and lessons learned from programs participating in life cycle cost procurement.

O&S costing research performed by the Logistics Management Institute provides important guidelines for standardizing O&S cost estimating and analysis for various categories of weapons. The Cost Analysis Improvement Group has released weapon system O&S cost element structures for ships, combat vehicles, and air-launched tactical missiles. They are also in the process of preparing O&S cost guidelines that are scheduled for release starting December of 1977.

Life cycle cost analysis of aircraft turbine engines, performed by the RAND Corporation, shows promise in the methodology used to allow a relative assessment of the difficulty in obtaining advanced engine performance and the attendant cost and schedule risks. Their analysis shows that base and depot maintenance costs are the main reason for high O&S costs and recommends that the Air Force change their present repair and manning policies. Analysis of commercial airline operational and maintenance practices shows good potential to military applications. Engine power management and on-condition maintenance are recommended throughout all using commands of the Air Force.

The three selected case studies provide encouraging results that life

cycle cost management does work. The cases selected provide a representative sample of the returns on investment being realized due to LCC management.

The Army's Black Hawk program is an excellent example of early logistics support planning. More importantly, this program is a success because management was willing to risk cancellation of their program by stopping work for one year to solve reliability and maintainability problems and provide a reliable system when fielded.

The F-18 program shows how the Navy can develop a system with enforceable reliability and maintainability requirements. The incentives provided for LCC management are key in providing credible trade studies aimed at minimizing total LCC. The contractor has realized approximately 60 percent of the incremental LCC management incentives to date and has predicted a life cycle cost avoidance savings of $228M.

The Air Force's ARC-164 program is a successful application of LCC procurement that is lower in cost than Reliability Improvement Warranty programs. Reliability by design and intensive testing provides lower performance warranty risk and reliable field operation. It was also found that only the negative aspects of initial and recurring logistics savings be incentivized and that at least one of the parameters of cost, reliability, and schedule remain flexible.

In conclusion, we are making progress in controlling the O&S costs and much hard work is ahead in furthering the techniques to implement LCC management. It will certainly require a dedicated commitment at all levels within the DOD and the Defense Industry to reverse the up-trend of ownership cost. Continued development is needed for costing methodology, procurement techniques, and tradeoff processes that will allow todays decisions on the acquisition of new systems for tomorrows defense.

ACKNOWLEDGMENTS

The author is pleased to acknowledge the assistance provided by the guest speakers of the September 1977 Life Cycle Cost Seminar, sponsored by the SOLE and AIAA in Dallas, Texas. Vue graphs were not immediately available at the seminar and a special thanks is due those speakers who provided me timely copies of their material which allowed me to meet the time constraints of this report. Special debts of gratitude are extended to Mr. Robert D. Dighton of MACAIR and Mr. William H. Boden of Magnavox who provided me invaluable information that allowed me to complete the case studies for the F-18 and ARC-164 programs. Thanks is also due Mr. Alvin M. Frager, OSD (MRA&L), who provided me with considerable help during telephone and personal conversations and provided current reference material. The author also acknowledges Hughes Aircraft Company for making it possible for me to attend the seminar in Dallas, Texas.

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Most of all, my deepest appreciation goes to my wife, Brucie, who not only typed my draft and final report but contributed immensely by editing and unselfishly providing assistance whenever needed.

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SECTION I

INTRODUCTION

The movement towards reversing the trend of increasing Operating and Support (O&S) costs is gaining momentum in all areas of the Department of Defense (DOD) and Defense Industry. With diminishing resources, it is becoming increasingly important that affordable systems be procured to counter the threat. There has been a steady shift in emphasis over the last decade from that of maximum performance capability at any cost to one of acceptable performance at an affordable cost.

Steady progress has been made in implementing the management initiatives that provide management guidance to control the total cost of our weapon systems. Development of the costing methodology continues to progress to the point that will allow todays decision making for the acquisition of tomorrows systems with full consideration of the cost of ownership. Up until recently, Design to Cost has only been applied to the acquisition phase. Today, we are addressing the operating and support costs to represent design to life cycle cost.

This study report concentrates on some of the advances made in the operating and support costing methodology research, and more importantly, analyzes how life cycle cost management, to include integrated logistics support, is being implemented on three of our on-going programs.

Purpose

This report provides an up-date on the progress to date in implementing the management initiatives that are directed at controlling O&S costs. O&S costing guidelines and methodology advancements are presented in summary form and highlight the major points as applied to this study.

The primary purpose of this study is to provide representative case studies of current programs that are implementing Life Cycle Cost (LCC) management.

Scope

To accomplish the purpose of this report, a summary is provided on the historical progression of the directives and memoranda that provide the policy guidance of todays LCC management. Costing guidelines and methodology research are presented with emphasis on the logistics consideration of commercial practices that may have military application. Three selected case studies are examined in detail to provide some insight of the LCC management techniques and the returns on investment being realized.

Methodology

The methods used to conduct this study includes literature research and attending a LCC seminar. The seminar provided sources for selection of representative programs for case studies involved with LCC management. Vue Graphs, provided by the speakers, served as the major source of information along with appropriate literature. Selected case studies were followed-up with telephone interviews for additional information and clarification.

Organization

This study is organized into five basic sections:

I. Section one provides a brief introduction of the content of the report.

II. Section two covers the recent management initiatives that are applicable to O&S cost and LCC management.

III. Section three is a summary of O&S Costing Guidelines that will be used by the Cost Analysis Improvement Group (CAIG) for standardization of O&S cost estimating and data collection. LCC methodology and analysis is provided from the RAND report on LCC analysis of Aircraft Turbine Engines and also touches on important tools provided to the designer by the Grumman Aerospace Corporation.

IV. Section four summarizes the 1977 Design to Life Cycle Cost Conference Seminar and develops three case studies; the Army's Black Hawk program, the Navy's F-18 program, and the Air Force's ARC-164 program.

V. Section five contains a summary and recommendations.

SECTION II

MANAGEMENT INITIATIVES

History

The acquisition of affordable weapons required the establishment of policy and guidance by the Office of the Secretary of Defense (OSD). Directives, memoranda, and circulars have been provided, aimed at reducing the outyear costs of our weapons.

Department of Defense Directives (DODD) have been revised to incorporate executive branch guidance, as specified in the Office of Management and Budget (OMB) circular A-109, that attempts to improve the process of acquiring major systems and provide a balance between acceptable performance, affordable total cost, and timely delivery.[2.1*] The 5000 series of DODD provides the majority of our present day policy used to guide todays acquisition of weapons. Deputy Secretary of Defense Clements's Memorandum of 28 February 1976 provides a major policy statement of DOD's objectives to reduce O&S costs and establish general approaches to managing outyear costs. This policy takes the approach of developing new weapons that cost less to operate and support than the systems to be replaced.[2.2]

Decisions on new weapons will be heavily influenced on their contribution towards reducing the fraction of the DOD budget allocated to weapon O&S costs while simultaneously maintaining operational readiness.[2.3]

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*The superscripts indicate the source of the information. In this case, 2.1 refers to the first reference under Section II in the List of References.

Summary of O&S/LCC Documents

A summary of the progression of the directives, memoranda, and circulars that are related to the management of O&S costs throughout the acquisition process is provided with a brief statement of their applicability towards reducing life cycle costs. [2.4]

July 1971 - DODD 5000.1 (Revised January 1977)

Cost shall be translated into design requirements. Revised to incorporate OMB A-109.

January 1973 - DODD 5000.3

Reliability, Maintainability and Logistics considerations will be tested.

June 1973 - DODD 5000.4

Cost Analysis Improvement Group (CAIG) established for cost credibility analysis.

September 1973 - Joint DTC Guide (Revised June 1976)

Provides joint service information and guidance for Life Cycle Cost discipline expanding on the concepts contained in DODD 5000.28. [2.5]

January 1975 - DODD 5000.2 (Revised January 1977)

Provides cost thresholds in Decision Coordinating Paper - Requires consideration of Logistics Alternatives. Revised to incorporate OMB A-109.

January 1975 - DODD 5000.26

Defense Systems Acquisition Review Council (DSARC) deliberations shall include design to cost and O&S cost considerations.

May 1975 - DODD 5000.28

Directs design to achieve the best balance between Life Cycle Cost, acceptable performance, and schedule.

February 1976 - Clements Memorandum

Major policy statement for reduction of outyear O&S costs. [3.1]

April 1976 - Circular Number A-109. Office of Management and Budget.

Broad statement of policies to govern executive agencies in the acquisition of major systems. [2.1]

The recent revision to DODD 5000.2 include the addition of enclosure 2, which covers the need for a one page logistics annex for milestones I, II, and III. It also includes DSARC and (S)SARC milestone reviews covering operational and logistics considerations through milestone III. The primary thrust being the inclusion of logistics as an equal parameter for consideration when performing system tradeoffs during early development and to ensure adequate logistics readiness and support plans prior to operational deployment. [2.4]

DODD 5000.28 serves as the cornerstone document in establishing the Design to Cost principles as we know it today. The major points of this document are:[2.6]

- Early visibility of LCC tradeoffs in establishing of unit production goals. (No later than DSARC II)
- Establishment of Tracking O&S Cost Goals.
- Establishment of O&S cost related Thresholds and Parameters:
  - Initial Logistics
  - Reliability and Maintainability
  - Personnel

- Visibility of business approach to incentivize reductions in LCC.
- Verification of O&S cost goals and thresholds during Test and Evaluation.

There are several 5000.xx directives in draft form aimed at establishing uniform policies for O&S costing discipline. Some of the items being considered include O&S cost information systems, assessment of the outyear O&S cost impact of program decisions, improving O&S cost evaluation, management techniques in the procurement process, and designation of a point of contact for LCC management.[2.4] The directives are presently being reviewed by logistics personnel within the MRA&L's logistics readiness division and are scheduled for release in the near future.[2.7]

SECTION III

O&S COSTING GUIDELINES AND METHODOLOGY

This section covers O&S costing guidelines that were prepared by the Logistics Management Institute (LMI) to be used by the CAIG in the preparation of standardized cost review and estimating methodology guidelines. The CAIG has already released for use weapon system O&S Cost Element Structures to be used by the services for preparing and submitting cost estimates to the CAIG and DSARC. They cover aircraft, ships, combat vehicles, and air-launched tactical missiles.

A brief treatment of the methodology that Grumman Aerospace Corp. is using for LCC cost management is presented. They have provided some of the essential tools to the designer to allow cost to be treated as a real design parameter.

Of particular interest is the RAND study report on Life Cycle Analysis of aircraft turbine engines. The method used to relate available technology for the desired performance appears to have application on other systems besides engines. Also extracted from the RAND report is an analysis of the commercial airlines operational and maintenance practices and the potential applicability to the military.

DSARC/CAIG Review

The Defense Systems Acquisition Review Council (DSARC) is providing considerably more emphasis on LCC, and particularly O&S costs of defense systems as they are reviewed at the appropriate milestones. To support the credibility of LCC projections at appropriate DSARC reviews, the CAIG acts as an advisory body to the DSARC on all matters of cost. Their authority and responsibility includes review of independ-

ent and program cost estimates prepared by the Military Departments considering all elements of system costs including procurement, operations, and support. They are also responsible for establishing criteria, standards, and procedures concerning the preparation of cost estimates on defense systems to the DSARC.[3.1]

To support the DSARC/CAIG review of O&S cost impacts, the Logistics Management Institute (LMI) was tasked to develop O&S cost review procedures and estimating methodologies that the CAIG could use to develop cost guidelines.[3.1] Three O&S cost guidelines covering aircraft, ships, and combat vehicle systems were provided to the CAIG early this year. An additional report, prepared by LMI, covers sensitivity of Army helicopter O&S costs to changes in design and logistic parameters.

A memorandum from the CAIG, dated 31 August 1977, directs the use of Weapon System Operating and Support Cost Element Structures and Definitions for aircraft, ship, combat vehicles and air-launched tactical missiles. The Cost Element Structures are to be used when preparing and submitting cost estimates to the CAIG/DSARC and shall serve as the basis for collecting O&S cost data under the DOD's Visibility and Management of Support Cost (VAMOSC) program. Appendix A contains a sample cost element structure with definitions for air-launched missiles.[3.2]

The CAIG estimates that the revised aircraft guide will be issued late this year with the other guides for ships, combat vehicles, and air-launched tactical missiles scheduled for release early next year. The guides will contain many of the analysis provisions and reporting formats contained in the LMI guidelines for analysis. As such, it is recommended that the LMI guidelines be reviewed thoroughly with particular

emphasis on the System Program Definition Statement; requirements for a pre-CAIG meeting, to determine ground rules for the cost analysis to be conducted for the DSARC/CAIG review; and maintenance sizing methodology.[3.2]

LMI Cost Guidelines

The LMI guidelines are directed at providing consistent preparation of Support Investment (SI) and O&S cost estimates for major weapon systems. This will facilitate DSARC/CAIG review of SI and O&S cost issues to focus attention towards the management and reduction of out-year costs during the acquisition phase. A recommended cost analysis methodology is provided that covers the following:[3.1]

- Formulation of cost analysis.
- Conducting the cost analysis.
- Preparing and Interpreting results.
- Review at CAIG/DSARC meetings.

The guidelines contain a System Program Definition Statement (SPDS) that reflects how the system will be used and supported and provides essential assumptions and information underlying the cost estimates. It also establishes the basis for critical review of the mission requirements and the adequacy of the proposed design and support concepts. Areas of high technology risks and cost uncertainty are also highlighted. Appendix B includes a sample outline of an SPDS for an aircraft system.[3.3]

The guidelines allow the cost analyst freedom in selection of the cost estimating techniques or models to be used. Specific models for calculating or predicting costs are not provided. Instead, suggested criteria for comparing and selecting cost estimating models are provided.[3.3]

Grumman Aerospace Corp. DTC Methodology

The approach at Grumman to LCC management places responsibility directly on the design engineer for both performance requirements, as done historically, and now the cost of his design. Their method provides him with cost impact visibility early in the design process where the maximum savings can be realized. This enables him to perform the necessary cost and performance tradeoffs to meet the unit production design target and minimize total LCC.

The two key elements developed include mathematical models and the DTC manuals which provide the designer first-hand cost information in a form that he can readily apply to his particular design. The manuals are used during various stages of aircraft vehicle design and provide the important linkage between design performance and cost for production and operations/support.[3.4]

The design to cost estimating models use a large historical data base for fighter and attack aircraft and provide excellent correlation between predicted and actual historical costs of aircraft during development, production, and initial operating and support phases. The model tracks the total work breakdown structure from the total LCC program level, through the lowest component level. Cost estimating relationships provide the correlation between performance parameters such as weight, thrust, spe i, etc. and total life cycle cost. The model is continuously updated as new information is obtained such as technology changes, production cost changes and the like, and provide the dynamic baseline used to develop and update the DTC manuals.[3.4]

The manuals are the key tool that provide the designer with appropriate design information for the particular subsystem of concern. There are numerous volumes covering the various subsystems that allow the design process to proceed with the appropriate trades between performance and cost.

The typical design process proceeds with requirements for the design task at hand. Using a shear panel design as an example, he is given the appropriate dimensions, shear loading, structural support spacing and the goals in terms of manhours for cost and the appropriate weight allocation. Various tables and charts with graphical relationships between cost and performance allow quick determination of the optimum points that must be reached to meet the established goals. Upon attainment of the established goals, the design is selected and other DTC manuals are used to develop detailed cost estimates for the various component parts and manufacturing processes to be used for the manufacture of the design.[3,4]

Grumman has made a large investment in developing and implementing a DTC methodology that places primary responsibility of cost with the design engineer. They have provided a very important tool for the designer that allows him to treat cost as a true design parameter and provide the engineering discipline required to maintain affordable systems.

RAND Aircraft Engine LCC Analysis

The RAND report, R-2103/1-AF dated March 1977, covers Life Cycle Analysis of aircraft turbine engines that utilizes and expands on earlier

study tasks conducted by RAND. The study was performed for the USAF in 1975 and early 1976, utilizing data available through 1974. The objective of the study was to develop a methodology for assessing life-cycle benefits and costs and apply that methodology to improve understanding of policy options for future engine acquisition and ownership. The procedure used was to develop a theoretical framework for each phase of the engine life-cycle, collecting and analyzing a large data base to develop parametric cost estimating relationships, and identify the relevant cost-drivers and their effects on life cycle cost. The findings of the study are summarized in this study report with emphasis on commercial airlines operational and maintenance practices and their potential applicability to the military.[3.5]

Life-Cycle cost elements

The life-cycle cost elements used in the study include: 1) acquisition costs, comprising RDT&E and procurement portions of the acquisition phase including design, development, test and manufacture; 2) ownership costs to include operating and support maintenance costs for all base and depot activities; 3) weapon-system-related costs of fuel and attrition due to accidents and catastrophic failures.

Table 1 provides a classification of life cycle cost elements used in the study. Certain cost elements appear under the acquisition and ownership columns because of the cost elements being associated with either phase. (e.g. ECP's for modification or retro-fit during the acquisition or ownership phase.)

Table 1

CLASSIFICATION OF LIFE-CYCLE COSTS

Cost Element	Acquisition	Ownership	Weapon-System-Related
RDT&E	X		
Flight test	X		
Tooling	X		
Proc. of install engine	X		
Component Improvement Program		X	
Spare engine		X	
Spare parts (base/depot)		X	
Depot labor		X	
Base labor		X	
ECPS	X	X	
AGE (peculiar/common)	X	X	
Transportation	X	X	
Management	X	X	
Facilities	X	X	
Training	X	X	
Engine attrition			X
Fuel			X

Analysis

The study extends previous work on acquisition cost-estimation utilizing a time-of-arrival technique that assesses the effects of state-of-the-art changes on costs. The critical problem is the assessment of available technology for the product desired and the associated cost penalty for increased performance.

The methodology uses a multiple regression technique to obtain equations that predict time-of-arrival of a particular engine's parameters relative to the technology available. The statistical qualities of the model were very good from the standpoint of correlation and standard error. There is also correct correspondence with intuitive behavior predictions. The methodology of assessing performance parameters and determining whether it is ahead or behind its time allows a relative assessment of the difficulty in obtaining an advanced engine and the attendant cost and schedule risks.

Overhaul Cost

Depot and Base level repair costs were analyzed to determine overhaul costs and appear to cost from 10 to 20 percent of the current procurement cost of the engines. Modifications to correct serious flight deficiencies also add to the cost. It is estimated that an engine can go through overhaul at the depot from three to six times or more during a fifteen year operational life cycle. When considering the single overhaul cost, added support costs, and frequency of depot visits, the results indicate that total depot cost for an engine during a fifteen year life cycle can exceed its procurement cost.

Commercial Life-Cycle Process

Comparing the commercial practices of engine life cycle experience with the military provides distinct differences in the procurement, useage, and maintenance concepts.

The procurement and warranty practices differ between the military and commercial world in several areas. When an airline purchases an engine from a manufacturer, the price generally includes portions of cost for design and development, incremental costs for component improvement, IR&D, and a margin for warranty on the engine. Conversely, the military pays for the development, component improvement, and IR&D seperately, generally with no warranty coverage except for failures of a brand new item.

When comparing the time-of-arrival of commercial engines compared to military engines, we see about a two and one-half year lag for the commercial engines. Two explanations are: 1) the commercial engine recieved the same performance at the same time with verification two and one-half years later, or, 2) the commercial engine traded reduced performance for greater durability, reliability, and maintainability. There does appear to be a different application of the technology base in designing for new commercial engines. The significance of this for military life-cycle-cost trends will require quantitative tradeoffs among aspects of durability, reliability, maintainability, and performance when designing new engines.

Operational Practices

Commercial operational practices differ considerably in the way engine power management is used by the airline pilots. Airline flight

crews are required to monitor engine performance in flight and provide essential data for trending analysis. Careful throttle management enables the airlines to achieve important dollar savings by trading performance for temperature stresses on engine parts. The Air Force could accomplish the same type of savings in engine wear even with a nominal reduction in throttle excursions.

Maintenance Practices

The airlines maintenance practices have turned away from the military's hard-time philosophy of performing maintenance actions at predetermined intervals regardless of how the engine is operating. This is generally termed as on-condition maintenance. Current airline maintenance procedures fall into three areas of consideration:

1. Maintenance of life-limited, high-time parts.
2. Condition monitoring of certain non-safety-of-flight parts with no fixed time limits.
3. On-condition maintenance and condition monitored maintenance related to inspection activity and impact of safety-of-flight.

> The intent of the on-condition maintenance program is to leave the hardware alone as long as it is working well and symtoms of potential problems are not developing. This philosophy is not one of 'fly-to-failure' where safety-of-flight items are involved. 3.5

This program is designed to reduce the rate of engine shop visits and increase its on-aircraft availability.

There is some concern among airline officials that on-condition maintenance for current high-bypass* engines may have gone too far too fast.

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* Third generation high performance engine.

Their concern is that even though more operating hours are being obtained, they may have to pay a higher cost when the engine finally returns for repair. The problem is to determine that optimum point of maximum operating hours at minimum total cost and providing the required in-flight safety and performance. The choice is between a short fixed-time philosophy and on-condition maintenance approach of running almost to the point of failure.

Continued work is required to be able to determine exactly how much can be gained by spending more resources during development to improve operational capability and reduced ownership cost. Until the methodology improves to allow designing of engines for total life-cycle benefits, designing to unit production price is a reasonable alternative, provided that "artificial" design compromises are not allowed that reduce production cost at the expense of higher ownership cost.

The RAND report contains many recommendations for changing current practices of design and maintenance support that must be implemented if we are to be successful in reversing the ever increasing LCC of our systems. Increasing depot and base repair costs were cited as a major factor requiring reconsideration by the Air Force of present repair and manning policies. Additional emphasis is recommended to pursue on-condition maintenance practices throughout all using commands to further lower LCC.

SECTION IV

LCC MANAGEMENT IN THE DOD & INDUSTRY

This section provides a brief overview of a DTLCC seminar that was sponsored by the Society of Logistics Engineers (SOLE) and the American Institute of Aeronautics and Astronautics (AIAA). The seminar was held on 29 September 1977 in Dallas, Texas. Three selected case studies presented at the seminar were selected for additional research for this study report. The Black Hawk program, formerly known as the Utility Tactical Transport Aircraft System (UTTAS), provides a good example of the results obtained when logistics is treated as a system design parameter. The F-18 program illustrates some of the techniques used to control life cycle costs and the tradeoffs performed between cost and performance to achieve minimum LCC. The last case study covers the ARC-164 UHF Voice Communication Subsystem that was an early experiment by the Air Force in LCC procurement.

Overview of 1977 LCC Seminar

The speakers did an outstanding job of presenting the current state of LCC management throughout the DOD and the Defense Industry. Management initiatives, O&S costing methodology, LCC analysis, and O&S cost estimating verification provided a comprehensive review of the in-roads made towards reducing LCC of our defense systems. Lessons learned were presented on many of the current programs by representatives from the services and industry. The spectrum of systems discussed ranged from the total system level such as the F-18 and Navy Cruise Missile programs to the subsystem level of the ARC-164 UHF Voice Communication System of the Air Force.

Logistics Early

Perry C. Stewart, Director of Concepts and Analysis - Air Force Acquisition Logistics Division, gave an excellent presentation. He pointed out how they are working with the development community to ensure that weapon systems and support equipment are designed with logistics considerations to provide more reliable equipment at lower life cycle costs.

Traditionally, logisticians are included rather late in the design cycle to support the existing design and respond by designing the required support. What has been lacking is early involvement where logistics can influence the design before it freezes. This early logistics concept causes design for support rather than support for the design.[4.1]

Reliability by Design

The Navy's new approach of improving system reliability to increase combat effectiveness and lower life cycle costs was presented by Dr. Willis J. Willoughby, Assistant Deputy Chief for Reliability, Naval Material Command. Traditionally, performance has been the overriding factor with a sacrifice of reliability which was usually compensated for by logistics support. Experience has shown that achieving performance has never been a problem and is usually exceeded. However, reliability requirements are being missed by wide margins.[4.2]

Management awareness of the importance of reliability by design and not by chance is the new approach. Tailoring of specifications for essential reliability requirements with enforceable contracts are key to obtaining the desired results. Simplicity of design as well as adequate

time to reach design maturity are also important factors. Complex, high-risk, advanced concepts and parts, whose reliability have not been established, will seldom be justified as the Navy makes reliability its first consideration and then looks for alternatives to achieving performance.[4.3]

The F-18 program, to be discussed later, is one of the Navy's current programs that is under development with the new approaches to reliability by design and not by chance.[4.2]

The overall theme of the conference stressed the management of life cycle cost. Each speaker reinforced this theme with Perry Stewart providing an excellent description of what life cycle cost management really means. It is not the predicting of a number reflecting things that will happen ten to fifteen years in the future. Rather, it is the consideration of current and future cost consequences along with performance and schedule in making today's decisions on the acquisition of new systems.[4.1]

The three selected case studies from the conference will be discussed further to illustrate some of the successes achieved as well as lessons learned in the management of life cycle costs.

Army Black Hawk Program

When a program is determined to depart from the traditional ways of "logistics as an afterthought" and makes a commitment to embrace logistics early in design, success is inevitable! The Army's Black Hawk Program, previously known as UTTAS, is such a success story. Colonel J. R. Brier, Assistant Program Manager for Logistics, provided an in-depth review of

the Black Hawk program with emphasis on the results obtained in maintenance capability and support concepts.

The Black Hawk program management philosophy included logisticians as a participative active team member early in the development phase thus providing the maximum opportunity to capture LCC savings. The planning process to provide dollar resources early, and adequate time, are key to a successful program. When a program manager is willing to stop work for one year to concentrate on resolution of reliability and maintainability problems of the system,[4.5] it is evident of the commitment necessary to achieve a product with high reliability, availability, and maintainability.

Maintenance features are lessons in simplicity that should serve as models for other programs to follow. Equipment accessibility requires no removal of other units to facilitate access. Units from the same functional subsystem are physically collocated for easier troubleshooting and maintenance at the organizational level. Only ten common hand tools are required to perform all organizational maintenance. Other features such as an internal auxilliary power unit and integrated lubrication system provide additional desireable maintenance features.[4.4]

Maintenance is performed at three levels similar to Air Force programs. This is a new concept for the Army as compared to their usual four levels of maintenance. Adaptation of the commercial aircraft maintenance feature of on-condition maintenance has helped to increase periodic inspection intervals from one hundred to five hundred hours and still maintain the requisite performance and safety features. A built-in maintenance feature that provides maintenance personnel with

a visual color indication of rotor blade integrity due to cracks is a significant advancement towards flight safety. Other systems included in the on-condition maintenance approach include monitoring of the engine rotor blades, transmission, and main/tail rotor hubs.[4.4]

Interchangeability of components shows the impact of logistics considerations on the design process and the resultant support savings. There are no left-hand and right-hand fuel cells, or landing gear. The design is such that the same landing gear and fuel cell is used in either location. A single type of main rotor blade and tail rotor blade provides additional savings in logistics support. The engines and hydraulic pumps are of modular construction which allow easier maintenance and lower provisioning costs by sparing modular sections rather than complete engine assemblies.[4.4]

Support equipment underwent considerable scrutiny before new designs were allowed. The priority sequence first determined what equipment was in the inventory, and if it met the requirements, it was used. If it required modification at an economical cost, it was modified. If not available within the inventory, commercial off-the-shelf sources were screened. Tradeoffs were also performed to determine the most cost effective approach for ground support equipment or built-in aircraft capability. A built-in auxiliary power unit was selected to eliminate the need for electrical and hydraulic ground support equipment.[4.4]

Maintenance manuals that are part of the Army's Improved Technical Documentation and Training Program, are written for easy understanding. Typically, manuals are written by people with an engineering or college background resulting in manuals for people of similar education levels.

The maintenance manuals for this program were written to an eighth grade level of readability. Keeping it simple is not an easy task! Cross referencing is kept to an absolute minimum. Information presented to the maintenance man is all in one location; how long the task should take, manpower and tools required, and materials needed to perform the task all go towards providing simple instructions and improved maintenance and reduced O&S costs.[4.4]

Looking at the results of the Black Hawk program provides considerable evidence that systems can be developed at an affordable cost especially if logistics is part of the management team participating early in the development phase. Manpower reductions by sixteen men at the Combat Support Aviation Company level was also made possible providing considerable life cycle savings. The management process involved participation with the contractor, training command, and the user for true integrated logistics support throughout all levels of management.

Navy Life Cycle Cost Control F-18

Robert D. Dighton presented one of the more dramatic examples of implementing Life Cycle Cost Control for the F-18 aircraft.

The F-18/A-18 Hornet Multimission Fighter will be the Navys advanced fighter aircraft that will provide carrier-based fleet air defense and ground attack capability for close air support missions. It will replace the F-4 aircraft for the Navy and Marines and the Navy A-7 attack aircraft.[4.6] Early flights, during the development phase, are scheduled for September 1978 and a production go-ahead decision is expected to occur early in 1980. The prime airframe contractor is McDonnell

Aircraft (MACAIR) with Northrop as a major subcontractor for the airframe and General Electric subcontracting for the F404 engine.[4.7]

The new look in LCC management at MACAIR is highlighted by the follov' g:[4.7]

- LCC requirements are contractual and integrally tied to DTC and integrated logistics support requirements.
- Firm DTC unit production cost objective with incentives.
- LCC management and control incentives.
- Firm Reliability and Maintainability guarantees with incentives.
- LCC baseline established early and monitored continously.

The F-1ᶜ program includes the following elements against which LCC control is a· lied. Approximate percentages are shown for each of the major elements of cost:

<u>Development (10%)</u>

- Engineering development and test
- Eleven flight test aircraft
- Radar testbed
- Flight Test Support

<u>Production (34%)</u>

- 800 Aircraft
  - 430 Fighters
  - 310 Attack
  - 60 Trainers

Initial Support (12%)

- Initial Spares
- Trainers and Training
- Ground Support Equipment
- Technical Publications

O&S (44%)

- Personnel - Direct and Indirect maintenance and support
- Replenishment Spares
- Consumables
- Fuel
- Depot Rework for Avionics, Engine, and Airframe

The incentives for the LCC objectives are substantial. Maximum fee for the Full Scale Development (FSD) phase is fifteen percent of target cost. The DTC award/penalty is an 85/15 share ratio against the production contract target cost. The potential award fees to control O&S cost for LCC management and reliability/maintainability are $15M and $24M respectively for a total of $39M! The LCC management award fee is determined and awarded at six month intervals beginning in 1976 and ending in 1981. The award fee is determined unilaterally by the Navy with a provision for appeal by MACAIR. MACAIR has been averaging approximately sixty percent fee to date with continued improvement as the program progresses.[4.8] Reliability and maintainability award fees are planned for 1980 and 1981 when the system undergoes development and operational testing.

To evaluate the achievements of the LCC goals, both subjective and objective evaluation factors were identified. The objective factors

apply to reliability, maintainability, and unit production cost values. Subjective criteria were applied to management and engineering effectiveness in resolving LCC problems by performing DTC/LCC tradeoffs to achieve reductions of LCC during full scale development.[4.8] Additional factors include the ability to define acceptable warranty programs, control of subcontractor LCC parameters, and the acceptability of the Logistics Support Analysis Program. Contractual reliability and maintainability guarantees are as follows:* [4.7]

Reliability

- Air Vehicle MFHBF

  2.9 at 1200 cumulative flying hours. (DSARC III A)

  3.6 at 2500 cumulative flying hours. (DSARC III B)

- Mission Reliability:

  0.8 hours

Maintainability

- MMH/FH
  11.0 hours

- MTTR
  1.8 hours

- MTBMA
  0.5 hours

- Turnaround Time
  15 minutes

- Operational Availability
  80%

- Operational Readiness
  85%

* See Appendix C for definitions.

All of the guarantees for reliability and maintainability will be evaluated during development testing using actual test aircraft except operational availability and operational readiness. These criteria will be tested theoretically using predictions based on appropriate models.[4.8]

Trade Studies

The process of performing trade studies on the F-18 program allows decision making that considers the total LCC of the system. Parameters of design, reliability, maintainability, and weight are traded against development, unit production, and O&S costs with minimum LCC as the final objective. Figure 1 shows a typical example of a tradeoff performed on the landing gear wheel and tire. Flexibility is allowed during the trade process to increase weight and unit production cost on one hand and lower FSD and O&S costs on the other.

As of March 1977, 360 tradeoff studies were started with 186 completed and 93 cancelled. The total predicted cost avoidance savings for LCC resulting from the tradeoff studies are $228M with O&S accounting for $78M, production $140M, and FSD $10M.[4.7]

Key features of the tradeoff process include early initiation of studies, detailed analysis, and establishing credibility of the predicted savings prior to implementation. MACAIR controls the majority of the trade decisions and coordinates decisions with NAVAIR when required. Close coordination is maintained with NAVAIR through formal reporting of DTC and LCC and resident NAVAIR logistics and engineering personnel assist in the interface between the government and contractor.[4.8]

MAIN LANDING GEAR WHEEL AND TIRE TRADE STUDY 76-352-97

RESULTS

— LARGE TIRE SELECTED —

IMPACTS

RELIABILITY	NO CHANGE
MAINTAINABILITY	−0.030 MMH/FH
WEIGHT	+89 LB
COST	
FSD	−0.788 $\overline{M}$
PRODUCTION	+0.319 $\overline{M}$
O&S	−6.986 $\overline{M}$

LIFE CYCLE COST = —7.455 MILLION

REASONS

— O&S COST SAVINGS —

	NONCOMMON	COMMON	ΔCOST
• REPLACEMENT TIRES			
FIGHTER	59,888	85,908	−\$0.381 $\overline{M}$
ATTACK	36,910		
• REPLACEMENT BRAKES			
FIGHTER	4,104	5,830	−\$5.064 $\overline{M}$
ATTACK	3,096		
• OTHER O&S			
LABOR, POL, ETC.			−\$1.541 $\overline{M}$
TOTAL O&S SAVINGS			\$6.986

MCDONNELL AIRCRAFT COMPANY

Figure 1

Maintainability and Reliability

As part of the new trend in present-day development of weapon systems, maintainability and reliability are designed to firm requirements instead of goals reflecting the new Navy philosophy of reliability by design and not by chance. Dr. W. J. Willoughby has been instrumental in formulating the Navy's policies of improving intrinsic reliability of the system. Reference 3.4 provides a detailed presentation of the new Navy reliability philosophy.

To meet the requirements of aircraft turnaround and operational availability, considerable emphasis was placed on maintainability features. Avionics are one-deep chest height, hinged radome and track-mounted radar, hinged windshield for instrument panel access, quick engine removal on carrier deck (20 minutes - 4 man crew), and numerous provisions for equipment accessibility.[4.6] Another feature developed by MACAIR to meet aircraft turnaround time is a Consumables Status system that is centrally located to allow rapid monitoring of hydraulic fluid, engine oil quantity, and oxygen status. Fault isolation is facilitated by built-in test features including a maintenance data recorder system to allow rapid failed unit isolation.[4.8]

Logistics considerations are also evident by an internal auxilliary power unit for engine starting, thus eliminating separate ground support equipment. Another advance made is the elimination of separate left and right hand engines by mounting the engine driven accessories to the aircraft rather than to the engine.[4.6]

LCC Tracking and Visibility

A joint effort between the Navy and MACAIR provided the LCC model for cost prediction and reporting. The Navy provided the desired format

and equations plus operational and O&S factors to be used in developing the model. MACAIR developed the LCC model consisting of a top level cost model used for total system tracking, and a more detailed equipment level cost model that provides for subsystem cost tracking, logistics evaluations, and LCC trade studies.

Cost estimating techniques use a parametric model with appropriate cost estimating relationships derived from similar systems through regression analysis or from field experiences. As the system progresses through the development phase, detailed bottoms-up engineering estimates are prepared to provide increased cost estimating accuracy and credibility.[4.7]

Integrated Logistics Support (ILS) Planning

Another major change in DTLCC control that provides additional savings is to design in the necessary support early. Historically, logistics considerations are applied rather late during the development phase when design is essentially frozen thus providing mimimum opportunity for cost savings. Some of the significant ILS factors providing additional savings are:[4.7]

- Phased support whereby transition to organic support occurs as the system matures.
- Acquiring spares concurrent with production buys.
- Formalized technical publications after proven on operational equipment.
- Training tailored to the maintenance task.

Lessons Learned

MACAIR has been successful in implementing LCC management with the Navy on the F-18 program. It has taken a concentrated team effort with

total program personnel participation to develop credibility with the Navy and their subcontractors in the LCC reduction program. Emphasis has been placed on the high cost drivers to capture the higher potential percentage of O&S cost savings. The award incentives are directed at reliability, maintainability, and most importantly, the managing of LCC. Based on predicted total cost of ownership we see a weapon system that has all of the makings to reverse the trend of higher O&S cost.

Air Force ARC-164 Design to LCC

The Program Director at Magnavox, William H. Bodin, provided current status of the ARC-164 program at the September 1977 DTLCC Seminar. This program was particularly interesting since it represents an early application of LCC procurement.

The ARC-164 program was started by the Air Force as an experiment in LCC procurement. In 1972, qualification contracts were awarded to three competing contractors for a replacement radio for the aging ARC-27's and ARC-34's. Selection for the production contract was based on selecting the system with the lowest predicted LCC. The Air Force developed their own LCC model which would be used to determine the successful contractor for the production contract. Magnavox won the competition and started the production contract on April of 1974.[4.10]

LCC procurement for the ARC-164 included the cost of acquisition, initial logistics, and recurring logistics (maintenance repair costs) with an award/penalty incentive as shown in figure 2. The incentive structure was based on the percent savings of initial and recurring logistics cost against the estimated value of savings. There is a dead zone of plus or minus three percent and a maximum bonus or penalty of

25 percent of the Acquisition Cost (AC). At the outset of the program the bonus zone looked desirable. Experience, however, has shown that the maximum possible bonus with an infinite MTBF is only four percent. This was a result of the initial logistics investment cost being larger than the recurring and essentially fixed after being purchased. This leaves a small variable recurring logistics cost against which to realize potential savings. Magnavox has estimated their present position to be in the no-contest dead-zone.[4.9, 4.11]

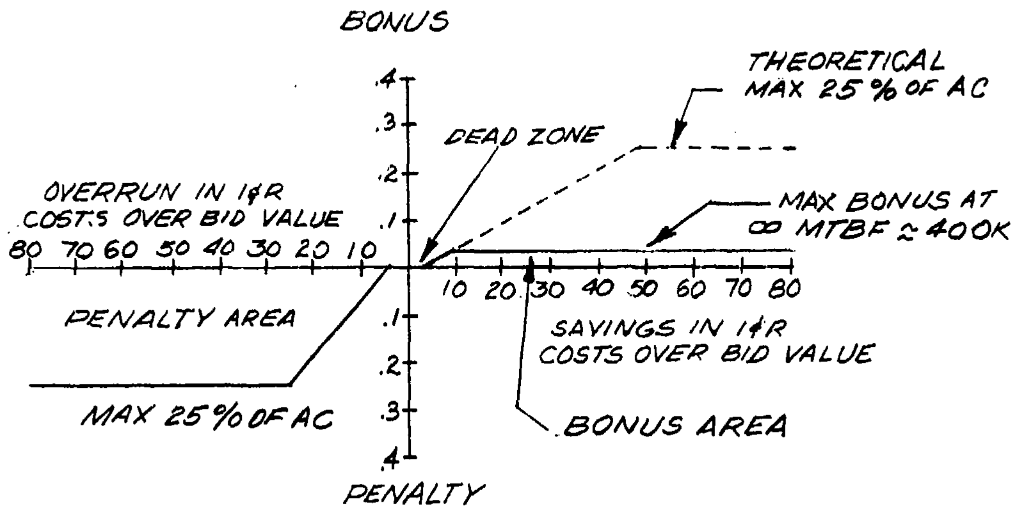

Figure 2

Reward Penalty Incentive
(50/50 share ratio)

The incentive on MTBF is directly related to the award/penalty curve shown above. Contractual MTBF requirements include a predicted field MTBF of 1200 hours, a factory MTBF of 1000 hours and a threshold MTBF penalty of 800 hours. Two lots of 60 systems were selected for LCC verification testing from the first years production and first

quarter of the second years production. Systems are installed on Air Force trainer, fighter, and transport aircraft and have been undergoing testing verification since January 1976. Field experienced MTBF (cumulative) is shown in table 2.[4.9]

A/C	Installations	Op. Hrs.	Failures	MTBF
T-37/-38	129	47,829	42	1138
C-130/-141	218	87,530	16	5470
F-100/-101	21	12,845	15	859
T-38	11	4,946	5	989
Totals	379	153,150	78	1,964

Table 2

Verification Test Results

Table 2 shows MTBF is well above the penalty value. There is, however, a considerable difference between transport and trainer/fighter aircraft. Investigations are in progress to determine the cause(s) and required solutions.[4.11]

Considerable savings in maintenance and support are being realized since the systems have been fielded. Over a two year period, maintenance manhours per flight-hour have been drastically reduced. Logistics cost savings are very good and Base and Depot repair personnel have been reduced by fifty percent. Collateral savings of fuel and engine maintenance have also been realized. The total savings for the Air Force is estimated at $1M per month.

The maintenance repair concept only allows removal and replacement

of faulty slice elements at the base level. One central depot provides worldwide repair support for all fielded equipment. Depot repair is accomplished by Magnavox trained and certified Air Force personnel. Another unique feature of this procurement is the one year failure free warranty provided by the contractor.[4.11]

Early in the design phase tradeoffs were performed that affected the maintenance concepts and, ultimately, the cost of operating and supporting the equipment. Slice construction instead of plug-in modules resulted in lower interface complexities and cost. The slice design construction allows identical functional modules such as the transmitter/modulater, main receivers and synthesizers to be used in the console/Panel-Mount Radio and the Remote Receiver/Transmitter unit. This approach also allows easy reconfiguring to allow adaptability to other vehicles and truly maintains a standard Line Replaceable Unit (LRU) which provides considerable savings potential. A disassembled view showing the unique slice construction and interchangeability is shown in figure 3.[4.9, 4.10]

Reliability was of paramount inportance during design to ensure the attainment of reliable operation and a successful warranty program. High reliability parts were used with intensive testing at the piece-part, module, and LRU level. Parts were screened by the vendors and during in-coming source inspection. A special purchased material inspection system was established for ARC-164 material screening with selected parts tested at high and low temperature extremes. One hundred percent slice level testing was conducted under computer control with appropriate feedback of trend data to manufacturing, design, and reliability engineering.

Another feature of the test philosophy was to maintain unit integrity throughout the complete test cycle. If a failure occurred, the LRU was removed from the test line until the failed slice was repaired and reinstalled in its LRU, thus maintaining testing integrity and minimizing retest cost. Internal testing to the requirements of MIL-STD-781 for the piece-part to module to LRU level could not be achieved. LRUs, however, are performing well above the penalty MTBF of 800 hours for all systems that are operating in the field. The 100 percent burn-in reliability testing philosophy helped to identify problems and reduce warranty risk and provided additional confidence in the fielded systems.[4.9]

UNIQUE ARC-164 SLICE CONSTRUCTION

IDENTICAL, SELF-CONTAINED, INTERCHANGEABLE MODULES

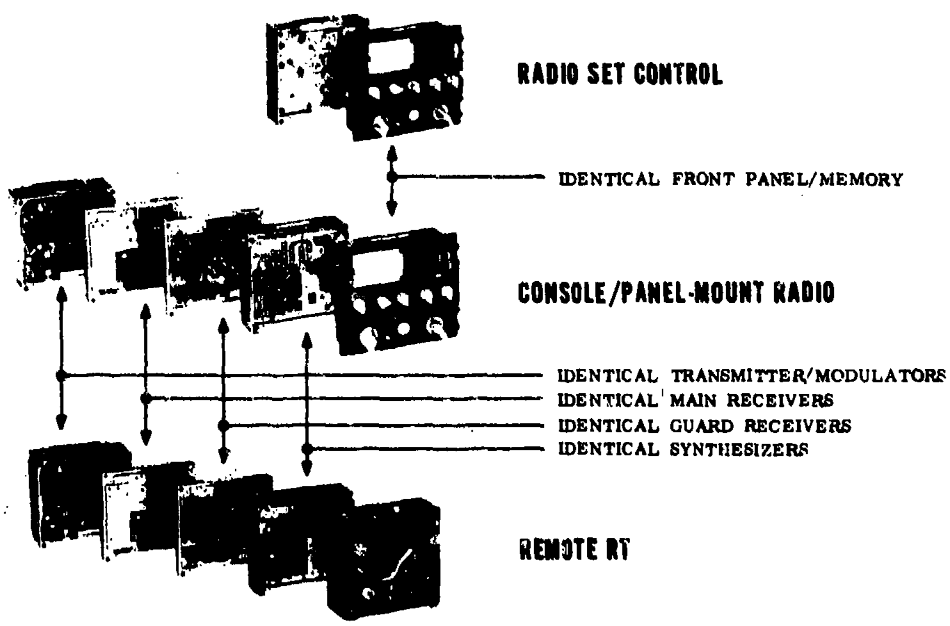

Figure 3

The LCC verification test program provided operational testing on selected production units to demonstrate contractual compliance of the required MTBF, MTTR and bonus/penalty incentive. This resulted in a concentrated effort of training of personnel and design of maintenance manuals. Air Force personnel were trained by Magnavox and certified for repair of ARC-164 equipment. Further, technical manuals were developed with all of the support personnel involved, all working towards delivering a simple and effective maintenance manual. Draft manuals were tested on contractor personnel prior to release to the Air Force.[4.9]

A corporate lesson regarding incentives is worth repeating regarding flexibility between price, schedule, and reliability. Magnavox found that at least one of the three factors must be flexible. Being a fixed price contract whose primary purpose was to provide reliable equipment left schedule as the only tradeable item. Unfortunately, the Air Force was unable to allow a slip in schedule due to a requirement for the ARC-164 in a new aircraft under development. If it were just for replacement of existing equipment the flexibility would have been available.[4.11]

In summary, there are several recommendations and lessons learned that should be highlighted:[4.9]

- Intensive equipment testing buys fielded reliability and the cost increase provides decreased warranty risk.
- LCC procurement is a lower cost approach to the Air Force than Reliability Improvement Warranty.
- Retain flexibility in at least one factor of Price/Reliability/Delivery.

- Incentivize only the negative aspect of initial and recurring logistics savings!
- Update MIL-STD-217/781 to more realistically reflect true field environments and procure for what is needed. Don't overspecify!

What started out as a pioneering effort in LCC procurement provided benefit to the Air Force and Industry. Both Magnavox and the Air Force are pleased with the results obtained to date in meeting the goals of this LCC procurement. The lessons learned from this procurement will undoubtedly serve as a model for LCC contracts that follow. This author doesn't mean to imply that the techniques used on the ARC-164 program will apply to larger systems. Each application must be looked at carefully in terms of applicability for the case at hand.

SECTION V

SUMMARY AND RECOMMENDATIONS

Our diminishing resources have forced us to search for alternative and innovative ways of acquiring affordable systems. The management initiatives from the OSD/OMB provide policy guidance and the Services are chartered with responsibility for implementation of the cost reduction initiatives. Industry assists by providing the systems or subsystems that are collectively integrated as a total weapon system. The same teamwork must hold true to reduce the ownership costs of our weapons.

The LMI studies provide a firm basis from which O&S costing[1] guidelines can be developed to assure a common approach of collecting O&S cost data and preparing the appropriate LCC estimates. Various models exist to assist in logistics support requirements, acquisition cost estimates, and even life cycle cost estimates. It must be realized, however, that predicting costs, especially ten to fifteen years in the future, is a very inexact process at best and more work is needed to refine the process. We can, however, proceed with relative cost tradeoffs that are manageable within todays technology of cost estimating.

The RAND report uses a time of arrival methodology that shows promise in being able to relate technology at hand to desired performance. It should be noted that to this date, no one has been able to specify exactly how much can be gained by expending more resources early in development to improve operational capability and reduce ownership cost.[3,5] The technique used by Grumman provides an important tool for the designer that allows direct control of cost by being able to relate the many design parameters with cost.

The Black Hawk program case study provides vivid results of what can be done when logisticians are an active team member. I am sure that the funding provided, and time allocated, were instrumental in the success achieved. Moreover, there is an over-riding factor that really makes it all happen. Management is the real driving force that underlies the success of any program!

The F-18 case study provides a current application of LCC cost control management showing some of the tradeoffs that are being done to minimize total LCC. The magnitude of the incentives for reliability and maintainability are very attractive. The incentive fee provided for management of Life Cycle Costs is evidence of the importance placed on LCC management. The new reliability policies initiated by the Navy are certainly going to pay off with improved operational availability of the weapons procured in the future. All of the services should follow the lead shown by the Navy.

The ARC-164 program has been a profitable venture for the Air Force and Magnavox from the standpoint of LCC procurement. The important lessons learned from this program should serve as models to follow for similar applications. Reliability improvements and intensive in-house testing appear to provide lower warranty risk and lower support costs. Only the negative aspects of initial and recurring logistics savings should be incentivized and at least one of the parameters of cost, reliability, and schedule must remain flexible.

In conclusion, the three case studies presented have shown positive results of logistics support involved early and influencing design decisions to provide the required reliability and maintainability to

field affordable systems. Design to Life Cycle Costs will certainly require a dedicated commitment at all levels within the DOD and Defense Industry to reverse the historical up-trend of ownership cost. Continued development and refinement is needed for the costing methodology, procurement techniques, and tradeoff process that will allow management to make todays decisions on the acquisition of new systems for tomorrows defense.

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APPENDIX A

AIR-LAUNCHED MISSILE OPERATING AND SUPPORT COST ELEMENT STRUCTURE

301 Operations
- 301.1 Operational Training
- 301.2 Handling and Inspection
- 301.3 Personnel Support

302 Below Depot Maintenance
- 302.1 Missile Maintenance Manpower
- 302.2 Munition Maintenance Manpower
- 302.3 Maintenance Materiel
- 302.4 Personnel Support

303 Installations Support
- 303.1 Base Operating Support
- 303.2 Real Property Maintenance
- 303.3 Personnel Support

304 Depot Maintenance
- 304.1 Manpower
- 304.2 Materiel

305 Depot Supply Support
- 305.1 Equipment Distribution
- 305.2 Equipment Management
- 305.3 Technical Support

306 Second Destination Transportation

307 Personnel Support and Training
- 307.1 Individual Training
- 307.2 Health Care
- 307.3 Personnel Activities
- 307.4 Personnel Support

308 Sustaining Investments
- 308.1 Replenishment Spares
- 308.2 Modifications
- 308.3 Replenishment Ground Support Equipments

AIR-LAUNCHED MISSILE OPERATING AND SUPPORT COST ELEMENT DEFINITIONS

300 OPERATING AND SUPPORT: The variable cost of supporting the air-launched missile operation of a deployed aircraft unit. 1/

301 OPERATIONS

301.1 Operational Training: The cost of: a) operational firings including such costs as range operation, instrumentation, drone and recovery costs; b) captive flight training planing, scheduling and evaluation costs.

301.2 Handling and Inspection: The cost of manpower and consumable materiel needed to conduct missile launch and recovery operations in the deployed unit. Included are such tasks as: Removing missiles from storage; missile inspection; missile assembly; transporting missiles to the aircraft; missile uploading; and missile check out and arming prior to a captive flight or firing. This cost also includes a similar series of tasks to download the missile and return it to storage if not fired.

301.2.1 Manpower: The pay and allowances of missile handling and inspection personnel.

301.2.2 Materiel: The cost of materiel consumed in the missile handling and inspection operation. Excludes the cost of reparable spares which are included in cost element 308.1, Replenishment spares.

301.3 Personnel Support: The cost of supplies, services, and equipment needed for support of missile handling and inspection personnel. Included are administrative supply items; expendable office machines and equipment; custodial services; and personnel-oriented support items such as desks and chairs.

302 BELOW DEPOT MAINTENANCE

302.1 Missile Maintenance Manpower

302.1.1 Organizational/AIMD: The cost of paying the personnel needed for maintenance of aircraft missile release systems; missile and missile components; and missile support equipment of the deployed aircraft unit. Included are the costs of supervisory personnel needed for such functions as missile-related maintenance supervision and control; missile quality control; and missile maintenance analyses.

302.1.2 Intermediate Maintenance: The cost of paying the personnel needed for missile and missile component checkout and repair at Naval Weapon Stations and Mobile Missile Maintenance units.

302.2 Munitions Maintenance Manpower: The cost of paying the personnel needed for handling and maintenance of missile warheads. Included are the costs of personnel needed to supervise warhead maintenance, storage a disposal.

302.3 Maintenance Materiel: The cost of purchasing material from the General and System Support Divisions of the stock funds. This cost includes all non-reparable expense items consumed in the missile and warhead repair process. Excludes reparable spares costs which are included in cost element 308.1 (Replenishment Spares).

302.4 Personnel Support: The cost of supplies, services and equipment needed to support below-depot maintenance personnel. Examples of included costs are administrative supply items; travel expenses; expendable office machines and equipment; custodial services; and other variable personnel-oriented support costs incurred at the maintenance activities.

303 INSTALLATIONS SUPPORT

303.1 Base Operating Support: The cost of installation personnel necessary to directly support missile handling and inspection and below-depot maintenance personnel. Examples of installation functions which directly support the unit include food services, custodial services, supply, motor pool, payroll, ADP and communication operations.

303.2 Real Property Maintenance: The variable cost of construction, maintenance and operation of real property facilities and related management, engineering and support work including contracted services that support the missile handling, inspection, maintenance and storage functions.

303.3 Personnel Support: The cost of supplies and equipment needed to support installation support personnel. Examples of included costs are administrative supply items and expendable office machines and equipment.

304 DEPOT MAINTENANCE: The cost of manpower and materiel needed to perform missile and missile component and support equipment maintenance at DoD centralized repair depots and contractor repair facilities.

304.1 Manpower: The cost of paying the personnel needed to perform major overhaul; repair; modification; calibration; inspection; and storage and disposal of missile and missile components and support equipment. Includes a pro rata

share of variable depot facility overhead costs.

304.2 Materiel: The cost of materiel consumed in the depot overhaul, repair, inspection and storage and disposal process.

305 DEPOT SUPPLY: The cost of manpower and materiel needed to buy, store, package, manage and control the supplies, spares and repair parts used in operating and maintaining misssiles and missile components and support equipment; and to provide sustaining (service) engineering and technical data support for missile systems.

305.1 Equipment Distribution: The cost of manpower and materiel needed to fill requisitions for missile and missile support equipment supplies, spares and repair parts. Included are receiving, unpacking, storage, inspection, packing and crating and issuing costs.

305.2 Equipment Management: The cost of manpower and materiel needed to manage the procurement of missile and missile support equipment supplies, spares and repair parts and maintain control and accountability of these assets.

305.3 Technical Support: The cost of sustaining (service) engineering and technical data and documents needed to perform sustaining engineering and maintenance on missile and missile component and support equipment.

306 SECOND DESTINATION TRANSPORTATION: The round trip cost of transporting missiles, missile support equipment and reparable secondary items to the depot maintenance facilities and back to the operational unit, Naval Weapons stations or Service stock points; and the one-way cost of transporting repair parts from Service stock points to depot and below depot maintenance and supply activities.

307 PERSONNEL SUPPORT AND TRAINING: The variable cost of training, moving and providing health care for personnel needed to replace missile handling, inspection, below-depot maintenance and installation support personnel.

307.1 Individual Training: 2/ The variable cost of recruit and technical (skill) training including:

- o the pay of personnel in training who will replace missile handling and inspection, below-depot maintenance and installation support personnel
- o the cost of their instruction
- o the pay of instructor personnel

307.2 Health Care: The variable cost of providing medical support to: missile handling and inspection, below-depot maintenance, installation personnel and training

pipeline personnel including:

- o the pay of medical personnel who provide this support

- o the cost of medical materiel

307.3 Personnel Activities: The costs incident to the PCS of: missile handling and inspection and below-depot maintenance personnel either individually or as an organized unit; installation personnel; and training pipeline personnel.

307.4 Personnel Support: The cost of supplies, services and equipment needed to support instructor, trainee and medical personnel. Examples of these costs are administrative supply, expendable office equipment and machines, and custodial services.

308 SUSTAINING INVESTMENTS: The cost of procuring spares, modification kits and materiel and ground support equipment for missile support.

308.1 Replenishment Spares: The cost of procuring missile spares and repair parts which are normally repaired and returned to stock. In addition, this cost can include procurement of stock levels that are not provided by initial spares procurement.

308.2 Modification Kits and Materiel: The cost of modifying missiles, missile support equipment, and training equipment that are in the operating inventory to make them safe for continued operation, to enable them to perform their missions and to improve reliability or reduce maintenance cost. Includes spares.

308.3 Replenishment Ground Support Equipment: The cost of procuring missile ground servicing equipment, maintenance and repair shop equipment, instruments and laboratory test equipment, and other equipment items including spares. Covers such items as ground generators and test sets for missile checkout. These equipment demands are generated by a need to: (1) replace peculiar support equipment bought using procurement funds; (2) obtain common off-the-shelf ground equipment that are needed to support missile operations as production aircraft arrive in the operating inventory; and (3) replenish common ground equipment that is no longer useable.

NOTES:

1/ A deployed aircraft unit consists of any unit operating in the field for combat, training or other operating purpose. To determine the O&S cost of the air-launched tactical missile under consideration, a typical deployed aircraft unit operation will be assumed. The O&S estimate will reflect the portion of the aircraft unit O&S cost that is missile related as well as the variable O&S cost of training at National Test Ranges.

2/ Factory training provided by contractors at their facilities to qualify an initial cadre of skilled personnel to: (1) operate and maintain a missile system when operationally deployed or (2) initially man Services missile system-related training courses, is paid for by both investment and O&M funds. Contractor instructor pay and the cost of instruction at contractor facilities is categorized as an investment cost; the pay of Service military and civilian personnel attending the factory schools is an O&S cost.

APPENDIX B

BASIC OUTLINE OF A SYSTEM PROGRAM DEFINITION STATEMENT FOR AIRCRAFT SYSTEMS

A. MISSION PROFILE
   1. Primary
   2. Secondary

B. AIRCRAFT CHARACTERISTICS
   1. Performance characteristics
   2. Physical characteristics
   3. Expected operational life
   4. Crew requirements

C. ACQUISITION PROGRAM
   1. Design-to-cost goal
   2. Number of Aircraft
      a. Deployed
      b. Training
      c. Pipeline
      d. Attrition
   3. Production/Deployment schedule
   4. Contract commitments on support cost control
   5. Special considerations for multi-national application

D. DEPLOYMENT
   1. Peacetime
      a. Number of CONUS/overseas bases
      b. Number and types of deployable units per base
      c. Number of aircraft per Training/Deployed Units
      d. Flying program (Training/Deployed Units)
   2. Contingency/Wartime Capability
      a. Number of CONUS/Overseas bases
      b. Number and type of deployable units per base
      c. Number of aircraft per Training/Deployed Units
      d. Flying program (Training/Deployed Units)

E. SUPPORT CONCEPT
   1. Initial Support
      a. Organization (Note: For Navy and Marine Aircraft indicate land and carrier plans.)
      b. Location of initial operational unit(s)
      c. Use of contractor support
      d. Parts supply
      e. Initial training
   2. Mature System Support - For Each Echelon, Generally Described
      a. Organization (Note: For Navy and Marine Aircraft indicate land and carrier plans.)

E. SUPPORT CONCEPT (Continued)

- b. Functions performed
- c. Method of performance
- d. Skill requirements
- e. Support equipment requirements
- f. Workload

F. LOGISTICS GOALS

1. Weapon System Goals
   - a. Serial reliability
   - b. Aircraft mean time to repair
   - c. Operational ready rate
   - d. Number of organizational and intermediate maintenance personnel per unit
2. Subsystem Goals
   - a. Engines
   - b. Avionics
3. Component Goals
   - a. Radar
   - b. Inertial Navigation System

APPENDIX C

DEFINITION OF ABBREVIATIONS

AC	Acquisition Cost
AGE	Auxiliary Ground Equipment
AIAA	American Institute of Aeronautics and Astronautics
CAIG	Cost Analysis Improvement Group
DCP	Decision Coordinating Paper
DOD	Department of Defense
DODD	Department of Defense Directive
DSARC	Defense System Acquisition Review Council
DTC	Design to Cost
DTLCC	Design to Life Cycle Cost
ECP	Engineering Change Proposal
FSD	Full Scale Development
FSED	Full Scale Engineering Development
ILS	Integrated Logistics Support
IR&D	Independent Research and Development
LCC	Life Cycle Costs
LMI	Logistics Management Institute
LRU	Line Replaceable Unit
MACAIR	McDonnel Aircraft Company
MFHBF	Mean Flying Hours Between Failure
MMH/FH	Maintenance Manhours per Flying Hour
MRA&L	Manpower Reserve Affairs and Logistics
MTBF	Mean Time Between Failure
MTBMA	Mean Time Between Maintenance Actions

MTTR	Mean Time to Repair
NAVAIR	Naval Air Systems Command
O&S	Operating and Support
OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
RAND	Research and Development Corporation
RDT&E	Research Development Test and Evaluation
(S)SARC	Service System Acquisition Review Council
SI	Support Investment
SOLE	Society of Logistics Engineers
SPDS	System Program Definition Statement
USAF	United States Air Force
UTTAS	Utility Tactical Transport Aircraft System
UHF	Ultra High Frequency
VAMOSC	Visibility and Management of Operating and Support Costs

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